CRC Report No. 576

(2)

OCTANE REQUIREMENT INCREASE OF 1988 AND 1989 MODEL VEHICLES

August 1991
Revised: June 1992

COORDINATING RESEARCH COUNCIL, INC.
219 PERIMETER CENTER PARKWAY, ATLANTA, GEORGIA 30346

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OCTANE REQUIREMENT INCREASE OF 1988 AND 1989 MODEL VEHICLES

(CRC Project No. CM-124-88/89)

Prepared by the

1988/1989 Octane Requirement Increase Analysis Panel

of the

CRC-Automotive Octane Technology and Test Procedures Group

August 1991
Revised: June 1992

Automotive Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

TABLE OF CONTENTS

I. SUMMARY OF RESULTS

The octane requirement increase (ORI) of 34 1988 and 101 1989 model-year vehicles operated on commercial fuels in customer-like service has been determined. These ORI values were determined from the octane number requirements regardless of whether they were determined at maximum- or part-throttle.

At 15,000 miles, the mean ORI of the 1988 vehicles with full-boiling range fuels (FBRU) was 4.19 (R+M)/2 numbers, 4.99 Research octane numbers (RON), and 3.39 Motor octane number (MON). The ORI of individual vehicles ranged from no increase to 9.5 (R+M)/2 numbers.

At 15,000 miles, the mean ORI of the 1989 vehicles with full-boiling range fuels (FBRU) was 3.79 (R+M)/2 numbers, 4.44 RON, and 3.15 MON. Individual vehicle ORI ranged from no increase to 14.5 (R+M)/2 numbers.

A number of 1989 models submitted have shown a somewhat unusual ORI. They have a very slow increase in the first 10,000 miles of operation, increasing rapidly to a peak between 15,000 and 20,000 miles, then falling off in requirements. No reason was determined for this behavior.

II. INTRODUCTION

The need to study octane requirement increase (ORI) with unleaded gasolines became evident in 1970 when manufacturers announced that future cars would require catalytic converters to meet 1975 emissions standards and these vehicles would use an unleaded fuel of at least 91 RON. The Coordinating Research Council, Inc. (CRC) initiated a series of ORI programs in 1971 to study the effects of these vehicle, fuel, and emissions changes. Since that time, manufacturers have made many engine and vehicle changes to meet both emissions and fuel economy standards. Because of these continuing changes and the exclusive use of unleaded gasoline in new vehicles, the ORI programs have been continued.

The ORI data from 1971 and 1973 through 1984 models have been reported in previous CRC publications.[1-12] CRC sponsored a Society of Automotive Engineers (SAE) paper which reported 1985-1988 model data.[13] This report updates the 1988 model-year results with additional new data and summarizes the results for the 1989 model-year.

III. EXPERIMENTAL

A. Vehicles Tested

The 1988 model-year data include 34 vehicles, 30 passenger cars, and 4 trucks. This is an increase of 6 vehicles from the analysis conducted in the SAE paper [13]. The 1989 model-year data include the results of 101 vehicles, including 98 passenger cars and 3 light trucks. These vehicles were not selected to represent the distribution of vehicles for that model year; rather they were voluntary submissions by the participants, which are listed in Appendix A.

B. Mileage Accumulation

Mileage accumulation on the 1988 and 1989 model-year vehicles was conducted in typical customer service or with test cycles replicating customer service. All vehicles used commercially available unleaded gasoline. No attempt was made to segregate laboratory-to-laboratory effects.

C. Reference Gasoline

The octane number requirements of all vehicles were determined with unleaded average sensitivity full-boiling range fuels (FBRU). Vehicles were tested with the 1987/1988 CRC FBRU fuel series, the 1989/1990 CRC FBRU fuel series, or a fuel specially blended to approximate the CRC fuel series. The RON and MON properties of the fuels are shown in Appendix C, Tables C-1, C-2, and C-3.

A very limited number of 1989 vehicles were tested with other reference fuels, including the 1989/1990 CRC FBRSU fuels series and the ASTM primary reference fuels (PR). The FBRSU is the high sensitivity full-boiling range fuel and is shown in Appendix C, Table C-4.

D. Test Technique

Octane number requirements were determined under clean conditions (under 200 miles) and in suggested 5,000-mile increments up to at least 15,000 miles using the CRC E-15-88 and -89 test procedures. Octane number requirements were determined on all vehicles with FBRU fuels, but on only 20 of the 1989 vehicles with the FBRSU and PR fuels.

E. Data Analysis Technique

For this voluntary program, octane number requirements were determined at a variety of mileage accumulation intervals. The RON of these data were plotted at the mileage tested by the participants, and a best-fit curve was generated to obtain an estimate of octane number requirements at 0, 5,000, 10,000 and 15,000 miles. An example of a best-fit curve is shown in Figure 1. MON requirements and (R+M)/2 requirements were determined from the best-fit curve RON data using the appropriate RON to MON conversion tables in Appendix C. Because of the small number of 1989 vehicles tested with the FBRSU and PR fuels, the analysis will only consider FBRU results and will report results as an (R+M)/2 octane number for the primary analysis. Members of the Analysis Panel are listed in Appendix B.

IV. DISCUSSION OF RESULTS

A. 1988 Model-Year Results

Six additional cars have been added to CRC's data base of 1988 test vehicles, previously reported in the referenced SAE paper [13]. The addition of these cars reduced the mean ORI of the 1988 vehicles from 4.48 to 4.19 (R+M)/2 octane numbers. The ORI of the individual vehicles ranged from 0 to 9.5 (R+M)/2 octane numbers. Because of the small 1988 data base, no additional analysis will be conducted beyond the fleet and make summary. The ORI of the 1988 vehicles expressed in terms of RON and MON octane numbers was 4.99 and 3.39, respectively, and is summarized in Table 1. A histogram of ORI in terms of (R+M)/2 octane numbers is shown in Figure 2.

The mean unweighted octane number requirement of the 1988 ORI data fleet estimated at 15,000 miles was 85.1 (R+M)/2 for the 34 vehicles tested. This compares to a 50 percent satisfaction of 85.5 (R+M)/2 in the 1988 CRC Octane Number Requirement Survey. Mean best-fit RON estimates for initial octane requirements and estimates at 5,000, 10,000, and 15,000 miles are shown in Appendix D, Table D-1, for the FBRU fuel only.

B. 1989 Model-Year Results

ORI data have been analyzed for 101 1989 model-year vehicles. The mean ORI of these vehicles is 3.79 (R+M)/2 octane numbers, slightly lower than measured for the 1988 fleet. Expressed in terms of RON and MON, the mean ORI is 4.44 and 3.15 octane numbers, respectively, and is shown in Table 2. The ORI of the individual test vehicles ranged from 0 to 13.7 (R+M)/2 octane numbers. While four cars exhibited ORI's between 11.2 and 13.7 and could be considered outliers in some schemes of analysis, they have been included. A histogram of ORI in terms of (R+M)/2 octane numbers is shown in Figure 3.

The mean unweighted octane number requirement of 1989 ORI data fleet estimated at 15,000 miles was 85.8 (R+M)/2 octane numbers. This compares to a 50 percent satisfaction level of 85.1 (R+M)/2 octane numbers reported in the 1989 CRC Octane Number Requirement Survey. Figure 4 compares the unweighted distribution of 15,000-mile best-fit octane number requirements of the ORI fleet to the weighted distribution of octane number requirements in the 1989 CRC Octane Number Requirement Survey report and shows the distributions to be very similar. Mean best-fit RON estimates for intital octane requirements and estimates at 5,000, 10,000, and 15,000 miles are shown in Appendix D, Table D-2, for the FBRU fuel only. The best-fit data for the 1989 vehicles tested with FBRSU and PR fuels are shown for reference in Appendix D, Table D-3.

The 1989 model-year data base is sufficiently large to warrant analysis by make, and in several instances by engine type. These data are reported in Table 2, which shows that the means and standard deviations of the engine families are the same order of magnitude as for the makes, suggesting that ORI is highly randomized.

The ORI of the 1988 and 1989 vehicles at 5,000, 10,000, and 15,000 miles has been plotted on Figure 5. The results for the 1988 model vehicles are very consistent with past experience [13] and show that 68 percent of the octane increase occurs in the first 5,000 miles, while between 10,000 and 15,000 miles, the rate of octane increase is less than 0.1 (R+M)/2 numbers per 1,000 miles. For 1989, the average increase at 5,000 miles is only 45 percent of the 15,000-mile ORI value, and the rate of increase between 10,000 and 15,000 miles is 0.2 (R+M)/2 numbers per 1,000 miles. This was a result caused by a number of vehicles (seventeen), which exhibited very slow octane requirement increase in the first 10,000 miles of operation, but a sharp rise in requirement above 10,000 miles. Many of these vehicles had peak octane number requirements above 15,000 miles, and almost all showed a steep decline in requirements past the peak. Consultation with the laboratories which operated these vehicles did not uncover any cause for the anomaly.

C. Comparison to Previous Years

The following table shows the mean ORI, 95 percent confidence interval, and sample size for the 1980 through 1989 model years for the FBRU fuels.

Model Year	Number of Vehicles	FBRU Fuel ORI-(R+M)/2	95% Confidence Limits
1980	120	4.24	0.40
1981	86	4.29	0.41
1982	115	3.96	0.39
1983	79	3.62	0.47
1984	62	3.26	0.60
1985	40	3.45	0.80
1986	30	2.57	0.82
1987	41	3.30	1.00
1988	34	4.19	1.01
1989	101	3.79	0.54

REFERENCES

1. Coordinating Research Council, Inc., "Influence of Leaded and Unleaded Fuels on Octane Requirement Increase in 1971 Model Cars," CRC Report No. 445, March 1971.

2. Coordinating Research Council, Inc., "Octane Requirement Increase in 1973 Model Cars," CRC Report No. 476, February 1975.

3. Coordinating Research Council, Inc., "Octane Requirement Increase in 1974 Model Cars," CRC Report No. 485, June 1976.

4. Coordinating Research Council, Inc., "Octane Requirement Increase in 1975 Model Cars," CRC Report No. 498, July 1978.

5. Octane Requirement Increase in 1976 Model Cars, CRC Road Test Group Informal Study by J. D. Rogers, Jr., October 1979.

6. Coordinating Research Council, Inc., "Octane Requirement Increase in 1977 Model Cars," CRC Report No. 513, April 1980.

7. Coordinating Research Council, Inc., "Octane Requirement Increase of 1978 and 1979 Model Cars," CRC Report No. 526, April 1982.

8. Coordinating Research Council, Inc., "Octane Requirement Increase of 1980 Models Cars," CRC Report No. 531, June 1983.

9. Coordinating Research Council, Inc., "Octane Requirement Increase of 1981 Model Cars," CRC Report No. 535, November 1983.

10. Coordinating Research Council, Inc., "Octane Requirement Increase of 1982 Model Cars," CRC Report No. 540, September 1984.

11. Coordinating Research Council, Inc., "Octane Requirement Increase of 1983 Model Cars," CRC Report No. 545, November 1985.

12. Coordinating Research Council, Inc., "1984 CRC Octane Number Requirement Survey," CRC Report No. 544, December 1985.

13. SAE Technical Paper 892036, "Trends in Octane Number Requirement Increase", September 1989.

TABLES AND FIGURES

TABLE 1

INITIAL OCTANE NUMBER REQUIREMENT & OCTANE REQUIREMENT INCREASE AT 5,000, 10,000, AND 15,000 MILES

- 1988 MODEL YEAR -

		(R+M)/2				RON				MON			
		Initial	ORI			Initial	ORI			Initial	ORI		
		ONR	5,000	10,000	15,000	ONR	5,000	10,000	15,000	ONR	5,000	10,000	15,000
Total	mean	80.95	2.83	3.84	4.19	84.17	3.36	4.56	4.99	77.72	2.29	3.11	3.39
	std dev	2.54	2.08	2.59	2.87	2.99	2.49	3.08	3.41	2.10	1.68	2.10	2.34
Manufacturer A	mean	82.20	2.14	3.26	4.06	85.70	2.49	3.80	4.79	78.70	1.80	2.71	3.34
	std dev	2.24	1.38	2.13	3.17	2.65	1.57	2.42	3.69	1.85	1.20	1.85	2.65
Manufacturer B	mean	81.25	3.87	5.16	5.38	84.50	4.65	6.20	6.47	78.00	3.10	4.12	4.30
	std dev	1.92	2.15	2.54	2.64	2.29	2.58	3.06	3.18	1.54	1.72	2.03	2.11
Manufacturer C	mean	80.60	2.70	3.54	3.76	83.79	3.21	4.19	4.46	77.42	2.18	2.88	3.06
	std dev	3.03	2.24	2.83	2.97	3.53	2.68	3.36	3.52	2.54	1.80	2.30	2.42
Manufacturer D	mean	80.62	3.41	4.43	4.68	83.75	4.10	5.32	5.63	77.50	2.73	3.54	3.73
	std dev	1.95	2.30	2.44	2.45	2.33	2.78	2.95	2.96	1.57	1.83	1.93	1.94

TABLE 2

INITIAL OCTANE NUMBER REQUIREMENT & OCTANE REQUIREMENT INCREASE AT 5,000, 10,000, AND 15,000 MILES

- 1989 MODEL YEAR -

		(R+M)/2				RON				MON			
		Initial	ORI			Initial	ORI			Initial	ORI		
		ONR	5,000	10,000	15,000	ONR	5,000	10,000	15,000	ONR	5,000	10,000	15,000
Total	mean	82.05	1.70	2.89	3.79	85.51	2.00	3.40	4.44	78.58	1.40	2.38	3.15
	std dev	3.59	1.37	2.23	2.77	4.10	1.64	2.66	3.29	3.10	1.11	1.81	2.27
Manufacturer A	mean	81.73	1.15	2.10	2.94	85.07	1.34	2.47	3.41	78.40	0.95	1.74	2.46
	std dev	1.77	0.88	1.48	1.73	2.07	1.07	1.80	2.10	1.50	0.70	1.16	1.38
Manufacturer B	mean	83.71	1.74	2.90	3.59	87.44	2.05	3.39	4.18	79.98	1.43	2.40	3.01
	std dev	2.75	1.01	1.54	1.60	3.21	1.25	1.84	1.88	2.29	0.78	1.26	1.34
Manufacturer C	mean	80.93	1.81	3.13	4.20	84.27	2.11	3.68	4.90	77.58	1.50	2.58	3.50
	std dev	4.01	1.63	2.71	3.50	4.52	1.94	3.23	4.14	3.53	1.33	2.21	2.87
Manufacturer D	mean	82.50	1.70	2.78	3.60	85.93	2.01	3.32	4.30	79.08	1.39	2.23	2.91
	std dev	3.09	1.23	1.94	2.31	3.67	1.45	2.35	2.80	2.53	1.01	1.53	1.82
Engine B19	mean	85.06	1.59	2.65	3.30	89.08	1.84	3.05	3.83	81.05	1.35	2.26	2.78
	std dev	2.95	0.59	0.86	1.00	3.48	0.73	1.02	1.19	2.41	0.46	0.71	0.82
Engine C23	mean	78.57	1.67	2.85	3.52	81.51	2.04	3.44	4.25	75.63	1.31	2.26	2.80
	std dev	2.47	1.86	3.25	4.43	2.61	2.24	3.92	5.36	2.35	1.50	2.58	3.50
Engine C38	mean	78.66	1.92	3.70	5.33	81.62	2.18	4.26	6.13	75.69	1.65	3.15	4.54
	std dev	2.50	1.46	2.69	3.39	2.65	1.67	3.05	3.84	2.38	1.27	2.36	2.95
Engine D16	mean	82.18	1.32	2.36	3.34	85.74	1.50	2.76	3.87	78.62	1.13	1.96	2.81
	std dev	1.99	1.49	2.49	2.77	2.17	1.72	3.00	3.35	1.81	1.26	1.98	2.20

FIGURE 1

BEST-FIT-CURVE ORI ANALYSIS

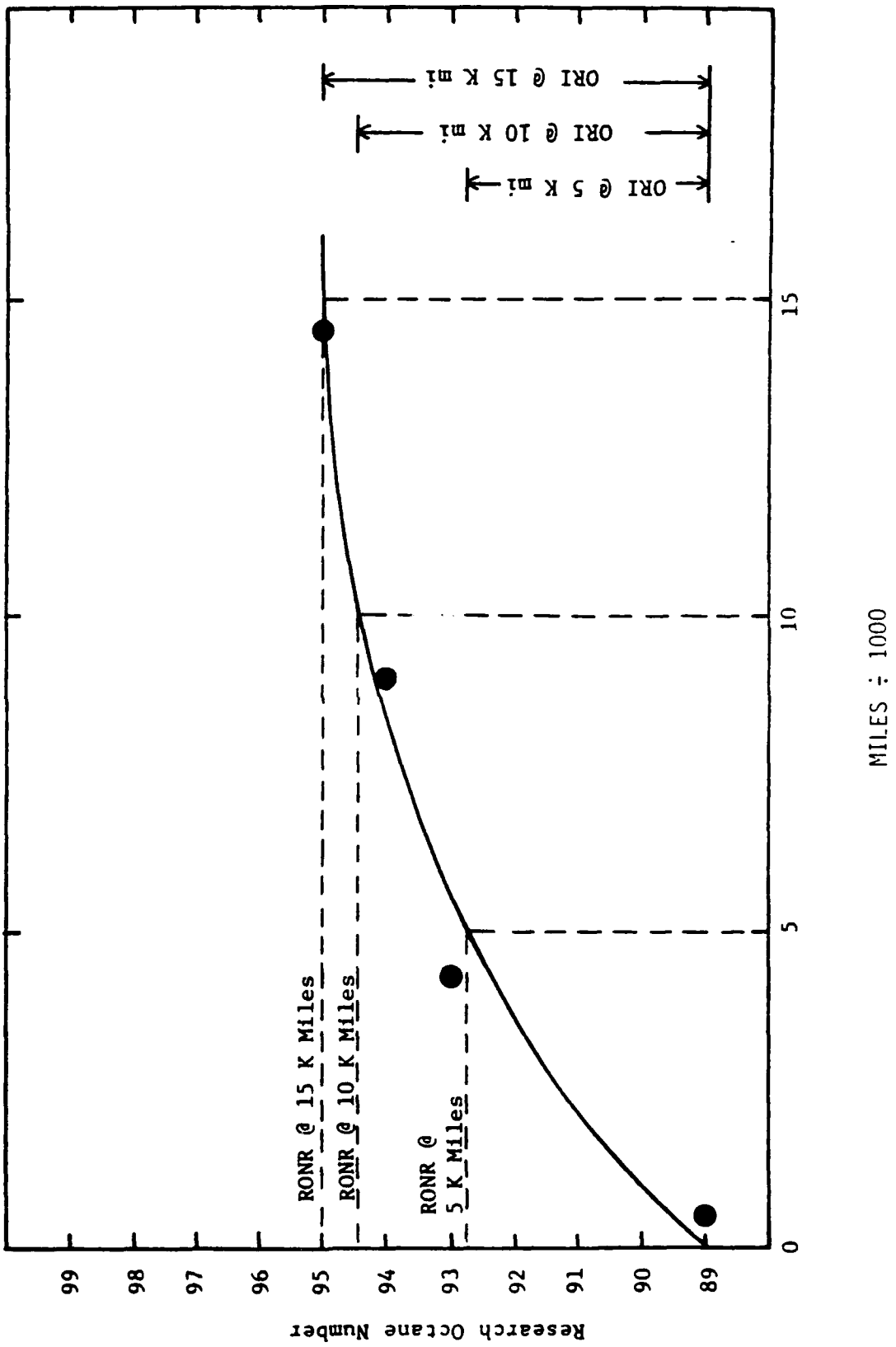


FIGURE 2

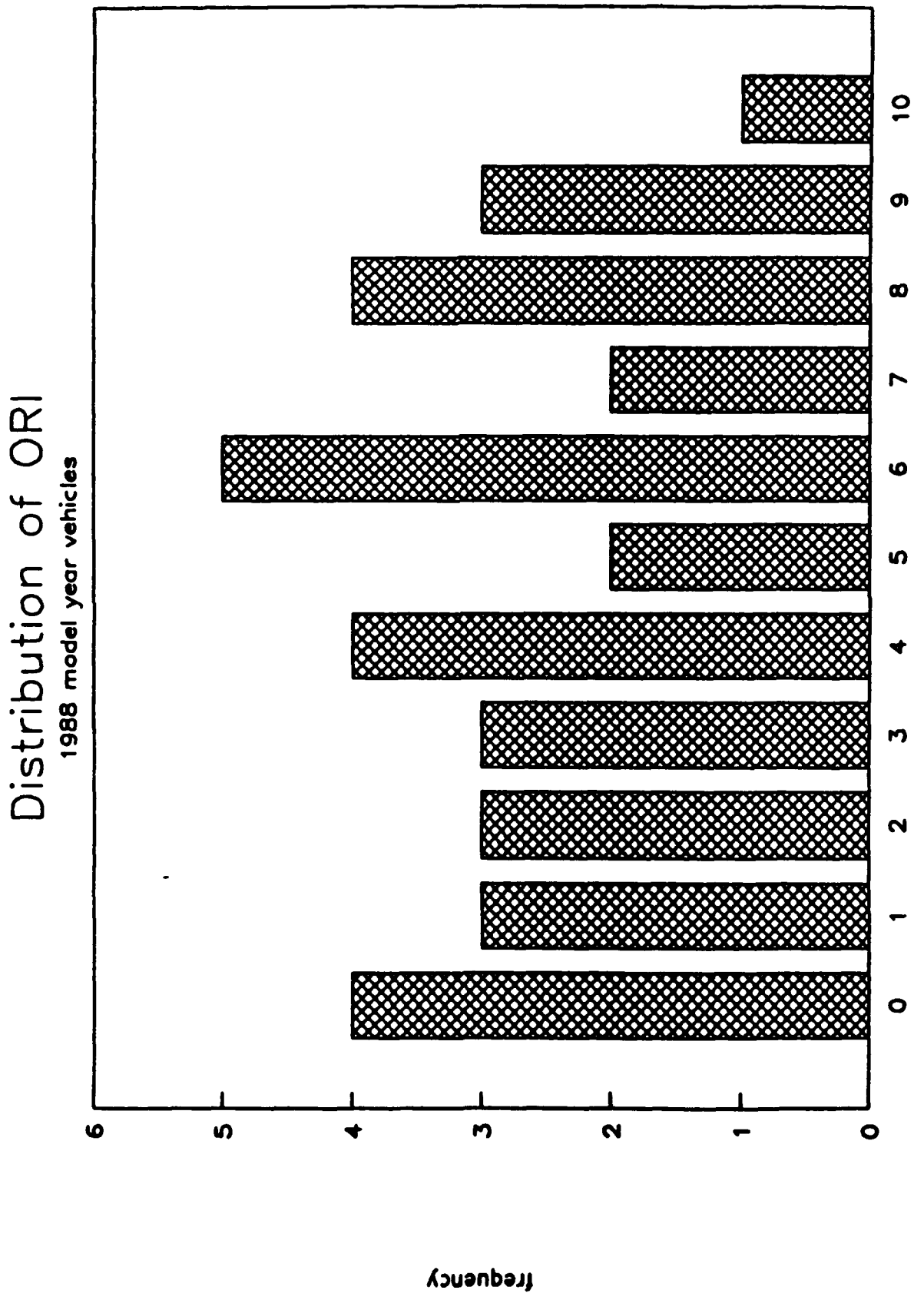

Distribution of ORI
1988 model year vehicles
frequency
0
1
2
3
4
5
6
ORI
0
1
2
3
4
5
6
7
8
9
10

FIGURE 3

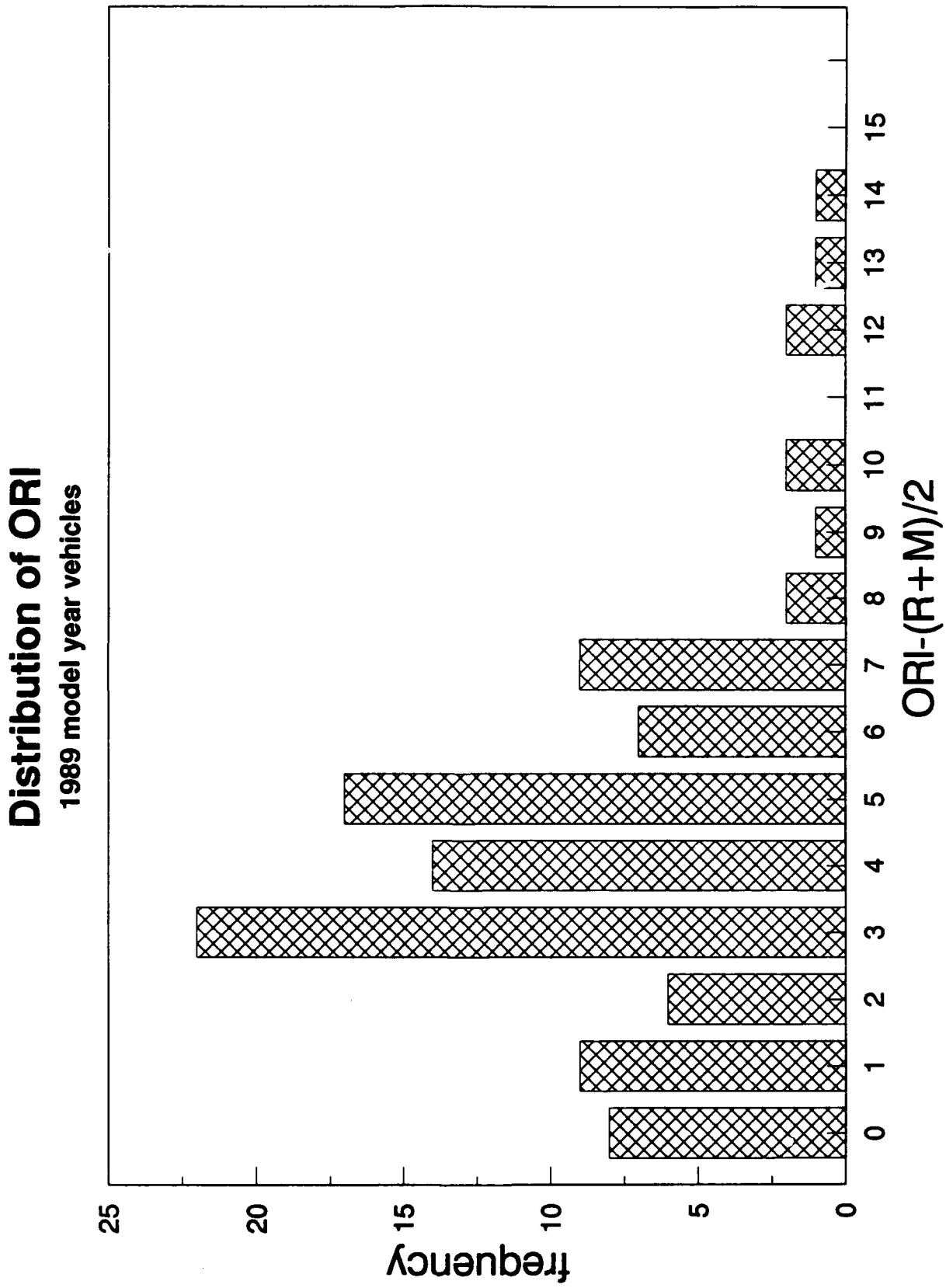

Distribution of ORI
1989 model year vehicles
frequency
0
5
10
15
20
25
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
ORI-(R+M)/2

FIGURE 4

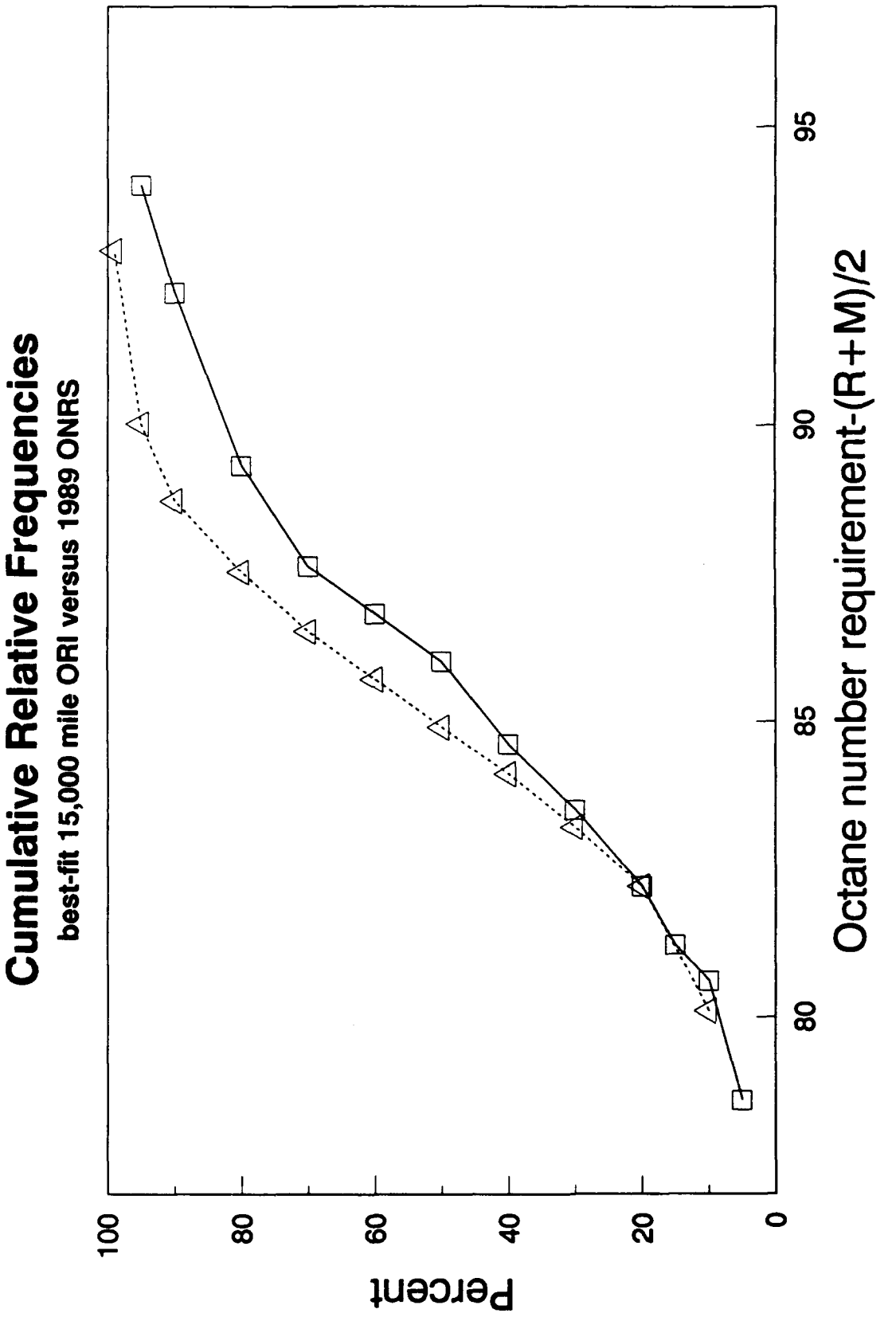
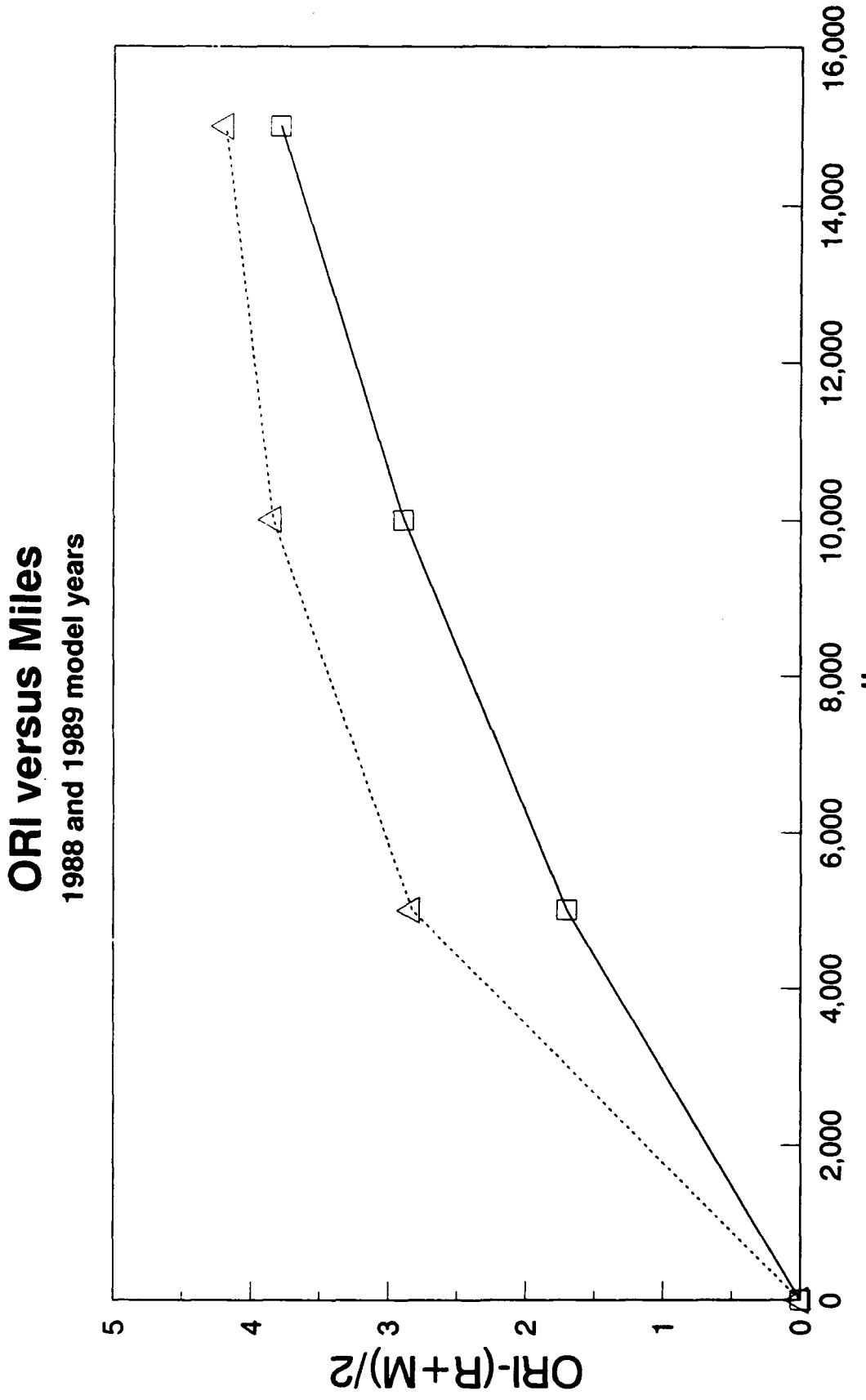

Cumulative Relative Frequencies
best-fit 15,000 mile ORI versus 1989 ONRS
Percent
100
80
60
40
20
0
80
85
90
95
Octane number requirement-(R+M)/2
Best-fit ORI
1989 ONRS

FIGURE 5


ORI versus Miles
1988 and 1989 model years
ORI-(R+M)/2
0
1
2
3
4
5
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
miles
1989
1988

A P P E N D I X A

LABORATORIES REPORTING OCTANE REQUIREMENT DATA AT VARIOUS MILEAGES

LABORATORIES REPORTING OCTANE REQUIREMENT DATA AT VARIOUS MILEAGES

Amoco Oil Company
Naperville, Illinois

BP Oil
Cleveland, Ohio

Exxon Research & Engineering Company
Linden, New Jersey

General Motors Research Laboratories
Warren, Michigan

Mobil Research & Development Corporation
Paulsboro, New Jersey

Texaco, Inc.
Beacon, New York

Unocal
Brea, California

A P P E N D I X B

MEMBERSHIP:

1988 AND 1989 OCTANE REQUIREMENT INCREASE DATA ANALYSIS PANEL

1988/1989 OCTANE REQUIREMENT INCREASE

DATA ANALYSIS PANEL

NAME	COMPANY
J. C. Callison, Leader	Amoco Oil Company
J. P. Uihlein	BP Oil
T. Wusz	Unocal

A P P E N D I X C

REFERENCE FUEL DATA

TABLE C-1

OCTANE NUMBERS FOR 1987/1988 CRC FBRU REFERENCE FUELS

Research Octane Number	Motor Octane Number
80	74.9
82	76.3
84	77.7
85	78.4
86	79.0
87	79.7
88	80.4
89	81.1
90	81.7
91	82.3
92	82.9
93	83.6
94	84.2
95	84.9
96	85.6
97	86.3
98	86.9
99	87.8
100	88.8
101	89.8
102	90.8
103	91.7

TABLE C-2

OCTANE NUMBERS FOR 1989/1990 CRC FBRU REFERENCE FUELS

Research Octane Number	Motor Octane Number
80	75.2
82	76.7
84	78.1
85	78.7
86	79.4
87	80.0
88	80.7
89	81.3
90	81.9
91	82.6
92	83.3
93	83.9
94	84.5
95	85.2
96	85.9
97	86.6
98	87.3
99	88.0
100	88.8
101	89.6
102	90.4
103	91.4
104	92.6

TABLE C-3

OCTANE NUMBERS FOR X FBRU REFERENCE FUEL

Research Octane Number	Motor Octane Number
78	72.4
79	73.1
80	73.9
81	74.7
82	75.5
83	76.3
84	77.2
85	78.0
86	78.8
87	79.6
88	80.4
89	81.3
90	82.1
91	82.7
92	83.3
93	83.8
94	84.4
95	84.9
96	85.6
97	86.3
98	87.1
99	87.8
100	88.5
101	89.3
102	90.2
103	91.6
104	93.1

TABLE C-4

OCTANE NUMBERS FOR 1989/1990 CRC FBRSU REFERENCE FUELS

Research Octane Number	Motor Octane Number
80	73.1
82	74.6
84	75.9
85	76.5
86	77.2
87	77.9
88	78.6
89	79.3
90	80.0
91	80.6
92	81.2
93	81.9
94	82.6
95	83.3
96	84.0
97	84.7
98	85.5
99	86.3
100	87.1
101	87.9
102	88.8
103	89.8
103.5	90.3

A P P E N D I X D

OCTANE REQUIREMENT DATA

TABLE D-1

1988 OCTANE REQUIREMENTS FROM BEST-FIT-CURVES - FBRU FUELS

Engine & Transmission Codes	Initial	5,000	10,000	15,000
t22a3	83.0	87.6	88.9	89.0
t22a3	90.0	91.0	91.0	91.0
p30a4	89.0	90.4	91.0	91.0
t22a3	86.6	89.1	93.0	97.9
t22a3	83.3	88.0	90.0	91.7
p40a4	84.0	84.4	84.6	84.8
t52a3	84.0	86.8	88.0	88.0
p30a3	86.0	87.8	89.0	89.0
p30a4	87.0	90.0	90.8	91.0
p30a4	84.0	91.6	93.6	94.0
p50a4	84.0	91.8	93.8	94.0
p16a3	86.0	87.7	88.8	89.0
p50a4	80.0	86.0	88.2	88.8
p28a3	88.0	93.3	94.8	95.0
t43a4	92.0	97.6	99.8	100.0
t20a3	84.0	89.8	91.5	92.0
p23a3	78.0	82.7	84.0	84.6
p23a3	82.0	84.2	85.3	86.0
p23a3	80.0	80.0	80.0	80.0
p23a3	84.0	86.0	86.0	86.0
p38a4	85.0	88.0	90.0	90.0
p38a4	82.0	82.0	82.0	82.0
p38a4	81.0	81.0	81.0	81.0
p38a4	82.0	87.7	89.6	90.8
p28a4	82.0	82.0	82.0	82.0
t50a4	85.0	87.0	87.7	88.0
t57a4	88.0	96.7	98.0	98.0
p20a4	84.0	85.5	86.0	86.0
t16a3	83.0	91.0	92.0	92.0
p30a4	80.0	83.6	85.2	86.0
115m5	84.0	86.5	88.0	88.0
p20a4	85.0	90.4	91.8	92.0
p20a4	85.0	87.3	89.6	91.0
p18m4	81.0	81.8	82.0	82.0

TABLE D-2

1989 OCTANE REQUIREMENTS FROM BEST-FIT-CURVES - FERU FUELS

Engine & Transmission Codes	Initial	5,000	10,000	15,000
tp25	87.0	87.9	88.0	88.0
p30a4	83.0	85.8	88.5	90.5
p30a4	86.0	88.0	89.6	90.5
t22a3	85.0	86.4	88.0	89.6
t22a3	87.3	88.0	89.0	90.5
t22a3	86.0	86.1	86.3	86.9
t22a3	82.0	82.7	83.6	84.9
t22a3	87.3	87.5	87.8	88.4
t39a3	82.0	85.3	87.0	87.0
p38a4	86.0	87.1	88.2	89.0
p30a4	87.0	89.0	90.0	90.0
p30a4	84.7	87.1	89.0	90.0
p30a4	83.7	86.3	88.9	90.8
p30a4	83.7	86.4	89.8	90.9
p30m5	87.0	89.4	92.0	93.0
t19	86.0	87.8	89.0	89.9
t19	87.0	89.2	90.9	91.9
t19	89.3	90.4	91.3	92.0
t19	95.0	98.0	99.0	99.6
t19	87.0	87.7	88.3	88.8
t19a3	89.0	91.0	92.3	93.0
t19	85.0	86.3	87.4	88.0
t19	94.3	96.9	98.8	100.0
p50a4	84.0	84.5	85.3	86.5
p50a4	84.7	85.3	86.2	87.7
p50a4	85.7	85.9	86.4	87.6
p50a4	84.7	85.1	85.8	87.0
p22a4	84.0	85.7	86.5	87.0
p22a4	86.0	87.0	87.0	87.0
p23a3	88.0	90.2	91.2	92.0
p30a4	93.0	95.5	98.0	99.8
p30a4	90.0	96.0	99.0	99.0
sp38a4	93.0	96.7	97.0	97.0
p50a4	86.0	89.5	90.6	91.2
p23m5	87.0	90.7	92.0	92.0
p30a4	90.0	91.5	92.5	93.0
t50a4	92.0	92.0	92.0	92.0
t50a4	86.0	86.0	86.0	86.0
t50a4	91.0	91.9	92.0	92.0

TABLE D-2 - (Continued)

1989 OCTANE REQUIREMENTS FROM BEST-FIT-CURVES - FERU FUELS

Engine & Transmission Codes	Initial	5,000	10,000	15,000
p28a3	87.0	91.6	96.3	101.0
p28a3	86.7	94.6	99.0	100.0
p38a3	84.0	86.4	88.9	91.4
p28a3	84.0	90.8	92.0	92.0
p38a4	86.0	88.3	90.1	91.0
p38a4	80.7	82.2	84.0	86.4
p38a4	80.0	80.0	80.0	80.0
p38a4	82.0	82.4	83.0	84.4
p38a4	85.0	89.5	92.7	94.0
p38a4	81.0	82.6	84.0	84.9
p38a4	79.7	80.7	83.0	85.6
tp20a3	90.0	90.0	90.0	90.0
tp20a3	90.0	90.0	90.0	90.0
p23a3	80.3	80.8	81.0	81.0
p23a3	79.3	79.3	79.3	79.3
p23a3	78.7	78.9	79.0	79.0
p23a3	80.3	80.3	80.3	80.3
p23	81.0	86.2	92.3	97.5
p23	87.5	89.2	90.5	91.0
p31a4	88.0	89.8	91.2	92.0
t25a3	79.3	80.5	82.0	84.3
t25a3	78.7	79.1	80.0	83.2
t25a3	80.7	80.8	81.5	84.0
t25a3	81.3	81.5	82.0	84.0
p28a4	82.7	83.9	85.0	85.8
p28a4	78.0	80.8	82.9	84.0
p28a4	80.3	83.0	84.0	84.0
p28a4	82.0	82.7	83.4	84.0
p33a4	88.0	91.0	93.0	93.0
p38a4	78.0	82.2	86.0	88.6
p38a4	78.0	83.0	88.0	92.6
p23a3	83.0	85.7	87.4	88.0
p23a3	82.0	88.0	89.8	90.0
p31a4	86.0	88.8	89.0	89.0
p33a4	92.0	94.1	95.7	96.0
p33a	87.0	89.4	91.2	92.0
p33a4	92.0	94.0	94.0	94.0
p33a4	92.0	94.5	96.5	97.0
p33a4	92.0	94.2	95.8	96.0

TABLE D-2 - (Continued)

1989 OCTANE REQUIREMENTS FROM BEST-FIT-CURVES - FBRU FUELS

Engine & Transmission Codes	Initial	5,000	10,000	15,000
t25a3	88.0	91.3	95.0	99.0
t25a3	90.3	93.3	96.0	98.7
p38a4	80.0	80.0	80.0	82.0
p38a4	85.0	88.3	90.8	92.0
p16a4	82.0	85.3	86.7	87.0
p16a4	84.0	86.6	88.0	88.0
215a3	82.0	84.8	85.0	85.0
220a3	91.7	94.2	97.0	98.9
220a3	89.0	90.2	93.0	95.7
215a3	96.0	96.0	96.0	96.0
p22a4	86.5	87.3	89.3	92.0
p22a4	84.5	87.0	87.0	87.0
t16a3	85.7	86.9	88.3	90.1
t16a3	87.8	87.9	88.0	90.3
t16a3	81.7	82.9	84.0	84.8
t16a3	88.0	88.0	88.0	88.0
t16a3	86.7	91.4	95.0	96.8
t16a3	84.0	84.0	84.0	84.0
t16a3	88.0	92.0	95.0	96.0
t16a3	84.0	84.8	85.7	86.9
p30	89.0	90.9	91.0	91.0
p25a4	81.0	84.3	87.3	89.0
p23a4	82.0	86.0	86.0	86.0

TABLE D-3

1989 OCTANE NUMBER REQUIREMENTS FROM BEST-FIT-CURVES

- FBRSU & PR FUELS

Engine & Transmission Codes	Initial ONR	FBRSU 5,000	FBRSU 10,000	FBRSU 15,000	Initial ONR	PR 5,000	PR 10,000	PR 15,000
t39a3	82.0	85.8	88.0	88.0	82.0	84.4	86.0	86.0
t19a3	90.0	92.0	93.2	94.0	89.0	91.0	91.0	91.0
p22a4	84.0	86.0	86.0	86.0	84.0	85.0	85.0	85.0
p22a4	85.0	86.5	87.0	87.0	83.0	84.7	85.5	86.0
p23a3	89.0	92.7	93.9	94.0	86.0	89.0	90.0	90.0
p50a4	86.0	89.5	90.6	91.2	85.0	89.2	90.6	91.2
p23m5	88.0	92.8	96.0	96.0	88.0	92.3	95.0	95.0
p30a4	92.0	93.2	93.8	94.0	88.0	89.8	90.3	92.0
t50a4	91.0	92.7	93.0	93.0	91.0	91.9	92.0	92.0
p33a4	90.0	93.6	96.0	96.0	87.0	88.8	90.0	90.0
p23a3	85.0	89.4	91.8	92.0	85.0	87.2	88.8	89.0
p23a3	85.0	88.0	90.7	93.0	82.0	84.7	86.0	86.0
p31a4	88.0	90.5	91.4	92.0	84.0	86.6	87.6	88.0
p16a4	82.0	85.3	86.7	87.0	82.0	85.3	86.7	87.0
p16a4	85.0	87.5	89.0	89.0	83.0	86.2	88.0	88.0
215a3	83.0	86.0	86.0	86.0	82.0	84.0	84.0	84.0
215a3	97.0	97.0	97.0	97.0	94.0	94.0	94.0	94.0
t16a3	90.0	90.0	90.0	90.0	88.0	88.0	88.0	88.0
p25a4	83.0	86.0	89.0	91.0	79.0	82.6	85.2	87.7
p23a4	82.0	87.0	87.0	87.0	82.0	84.0	84.7	85.0